
पूर्व प्रतिबलित कंक्रीट के लिए तनाव
रहित कम शिथिलन वाले अलेपित सात-तार
(प्लाई) के स्ट्रैंड — विशिष्टि
(दूसरा पुनरीक्षण)

**Uncoated Stress Relieved Low
Relaxation Seven-Wire (Ply) Strand
for Prestressed Concrete —
Specification**
(Second Revision)

ICS 77.140.15; 91.080.40

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FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Concrete Reinforcement Sectional Committee had been approved by the Civil Engineering Division Council.

This standard has been published to cover the requirements of low relaxation seven-ply strands for prestressed concrete. These types of strands are capable of developing and retaining large concentrated prestressing forces. The low relaxation property is achieved by a process called stabilizing. This is essentially a hot stretching process, in which prestressing strand is subjected to a pre-determined tension during stress-relieving heat treatment. This results in linear hardening of the steel which substantially increases the resistance to creep and thereby reduces the relaxation losses.

The standard was first published in 1995 and subsequently revised in 2017. The first revision was taken up with a view of incorporating modifications found necessary as a result of use of this standard both by the manufacturers and the users. Time and again strand biting during tensile testing of strands were being reported on account of using improper gripping arrangements. In order to ensure that the criticality of proper gripping of strand to get correct test results is understood and applied by the industry, a need was felt for revision of the standard suggesting various gripping procedures and methods for minimizing these difficulties. In the first revision of the standard, following modifications were incorporated:

- a) Method for measurement of length of lay of strand was incorporated,
- b) Method for measurement of nominal diameter and difference in diameter of central wire and surrounding wire of strand was incorporated,
- c) Method for determining nominal cross-sectional area and nominal mass per unit length of strand was incorporated,
- d) 1.0 percent extension method for determining elongation was elaborated to provide more clarity,
- e) Methods to be adopted for minimizing difficulties of premature failure of the test specimens while conducting mechanical tests on strands were incorporated, and
- f) Various methods of gripping test specimen for tensile testing of strands were suggested.

This revision of the standard has been taken up to update it so as to take into account current practice of manufacturing and use. The following major modifications have been incorporated in this standard:

- a) Compacted and indented strands have also been covered in addition to plain strands already covered in the standard;
- b) Requirement for wire rod to be used for drawing wires has been specified;
- c) Nominal sizes have been aligned with international practices, taking care to include sizes close to those already being manufactured in the country. Accordingly, sizes 6.4, 6.9, 7.0, 8.0, 8.6, 9.0, 9.3, 9.6, 11.0, 11.3, 12.5, 12.9, 13.0, 15.7 and 18.0 mm have been added, and 9.5 and 11.1 mm have been deleted;
- d) Strands of higher tensile strengths have been added, and therefore the existing classification of strength grades as Class 1 (1 770 MPa) and Class 2 (1 860 MPa) has been deleted, however, these tensile strengths have been retained;
- e) Requirement for straightness of strand has been added; and
- f) Requirement for behaviour of strand at the time of their cutting has been added.

In the formulation of this standard, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country. Assistance has been derived from the following International Standards in the formulation of this standard:

ISO 6934-1 : 1991	Steel for the prestressing of concrete — Part 1: General requirements
ISO 6934-4 : 1991	Steel for the prestressing of concrete — Part 4: Strand

(Continued to third cover)

Indian Standard

UNCOATED STRESS RELIEVED LOW RELAXATION SEVEN-WIRE (PLY) STRAND FOR PRESTRESSED CONCRETE — SPECIFICATION

(*Second Revision*)

1 SCOPE

1.1 This standard covers the requirements for manufacture, supply and testing of uncoated, stress relieved, low relaxation, seven-wire (ply) steel strands for prestressed concrete.

1.1.1 The following three types of strands are covered,

- a) Plain;
- b) Indented; and
- c) Compacted.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
1387 : 1993	General requirements for the supply of metallurgical materials (<i>second revision</i>)
1608 (Part 1) : 2018/ ISO 6892-1 : 2016	Metallic materials — Tensile testing: Part 1 Method of test at room temperature (<i>fourth revision</i>)
1956	Glossary of terms relating to iron and steel:
(Part 1) : 1976	General metallurgy, heat treatment and testing (<i>first revision</i>)
(Part 2) : 2018	Steel making (<i>second revision</i>)
(Part 3) : 2019	Long products (including bars, rods, sections and wires) (<i>second revision</i>)
(Part 5) : 1976	Bright steel bar and steel wire (<i>first revision</i>)

IS No.

Title

7904 : 2018 High carbon steel wire
rods — Specification
(*second revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 1956 (Part 1), IS 1956 (Part 2), IS 1956 (Part 3) and IS 1956 (Part 5) and the following shall apply.

3.1 Breaking Load — The maximum load reached in a tensile test of the strand.

3.2 Coil or Reel — One continuous length of strand in the form of a coil or reel.

3.3 Elongation — The increase in length of a tensile test piece under stress. In case of strands, the elongation is measured immediately prior to fracture of any of the component-wires and is expressed as the percentage of the original gauge length of a strand test piece.

3.4 Length of Lay — The distance (measured along a straight line parallel to the strand) in which a wire forms one complete helix.

3.5 Parcel — Any quantity of finished strand presented for examination and test at any one time.

3.6 Production Length — The maximum length of strand which can be manufactured, with or without welds, being made after drawing, in any of its component wire.

3.7 Proof Load — The load which produces a residual strain of 0.2 percent of the original gauge length (non-proportional elongation).

3.8 Seven-Wire (Ply) Strand — Any length of finished material which comprises six wires (plies) formed together in helical form around a central wire.

3.9 Indented Strand — Strand in which outer wires carry indentations of uniform dimensions on two sides, at uniform length and with no two indentations exactly opposite to each other. Core wire does not have any indentation.

3.10 Compacted Strand — A seven wire strand with plain surface, which after stranding is compacted either by rolling or drawing through a die, before stress relieving.

4 MANUFACTURE

4.1 Wire

4.1.1 The base metal shall be carbon steel of such quality that when drawn to wire, fabricated into strand and then stress relieved, shall have the properties and characteristics prescribed in this standard.

4.1.2 The element wire to be used for strand shall be cold-drawn from steel wire rods conforming to IS 7904.

4.1.3 The wire used in the manufacture of the strand shall be well and cleanly drawn to the specified dimensions and shall be sound and free from splits, surface flaws, piping and any other defect likely to impair its use in the manufacture of the strand and the performance of the strand in prestressed concrete.

4.1.4 In case of indented strand, the outer wires of the strand shall have oval type indentations with dimensions as given in Table 1.

Indentation shall be two sided, with the indentations in one row falling midway between two indentations in the opposite row. Central core wire shall be plain.

4.2 Strand

The seven-wire (plies) strand shall have a centre wire atleast 1.5 percent greater in diameter than the surrounding wires enclosed tightly by six helically placed outer wires with a uniform length of lay of atleast 12 times but not more than 16 times of the nominal diameter of the strand. The wires in the strand shall be so formed that they shall not fly out of position when the strand is cut without seizing. The length of lay of strand, nominal diameter of seven-wire (ply) strand and percentage difference in diameter of centre wire and surrounding wire of seven-wire (ply) strand shall be measured in accordance with the method given in Annex A.

4.3 Joints

4.3.1 There shall be no strand joints or strand splices in any length of the completed strand unless specifically permitted by the purchaser.

4.3.2 During process of manufacture of individual wires for stranding, welding is permitted only prior to or at the time of last heat treatment.

4.3.3 During fabrication of the seven wire (ply) strand, butt-welded joints may be made in the individual wires, provided there is not more than one such joint in any 45 m section of the completed strand.

4.3.3.1 When specifically ordered as weldless grade, a product free of welds shall be supplied. When this grade is specified, no welds or joints are permitted except as detailed in 4.3.2.

4.4 Treatment of Strand

4.4.1 After stranding, all strands shall be subjected to a continuous thermo-mechanical treatment to produce the prescribed mechanical properties.

4.4.2 Temper colours that may result from the thermal operation are considered normal for the finished appearance of this strand.

4.4.3 After thermo-mechanical treatment, the strand shall be reformed into coils or wound onto reels, having core diameter of sufficient size and in any case not less than 600 mm to ensure that the strand will lay out straight.

4.5 Workmanship and Finish

The finished strand shall be uniform in diameter and shall be free from injuries, flaws and imperfections. Slight rusting, provided it is not sufficient to cause pits visible to the naked eye, shall not be a cause for rejection.

5 NOMENCLATURE

The strand shall be designated on the basis of:

- a) Nominal diameter of the strand;
- b) Nominal tensile strength, that is, 1 670 MPa, 1 860 MPa, etc, as given in Table 2; and
- c) Type of strand, that is, plain (P), indented (I) or compacted (C).

For example, 12.7 mm indented strand with 1 860 MPa tensile strength will be designated as 12.7-1860-I.

6 DIMENSION, TOLERANCE, UNIT WEIGHT AND PHYSICAL REQUIREMENTS

6.1 The nominal diameter, tolerance, nominal cross-sectional area and mass per unit length of the strand shall be as given in Table 2.

6.1.1 The nominal diameter of strand shall be measured across the crown of the wires and in accordance with the method given in Annex A.

Table 1 Dimension of Oval Type Indentations
(Clause 4.1.4)

Sl No.	Nominal Strand Diameter mm	Nominal Depth mm	Tolerance on Depth mm	Length of Indentation mm	Spacing Between Indentations mm
(1)	(2)	(3)	(4)	(5)	(6)
i)	≤ 12	0.06	± 0.03	3.5 ± 0.5	5.5 ± 0.5
ii)	> 12	0.07	± 0.03	3.5 ± 0.5	5.5 ± 0.5

Table 2 Strand Dimensions and Physical Properties
(Clauses 5, 6.1, 6.2.2.1, 6.2.2.2 and 6.2.3)

Sl No.	Strand Designation	Diameter mm	Tensile Strength MPa	Cross-Sectional Area mm ²	Mass Per Metre g/m	Tolerance on Nominal Mass Per Metre Percent	Minimum Breaking Load kN	Minimum 0.2 Percent Proof Load kN
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	15.2-1670-P	15.2	1 670	139	1 086	± 2	232	204
ii)	18.0-1670-P	18.0	1 770	223	1 742	± 2	379	334
iii)	6.9-1770-P	6.9	1 770	29	226.5	± 2	51.3	45.1
iv)	9.0-1770-P	9.0	1 770	50	390.5	± 2	88.5	77.9
v)	9.3-1770-P	9.3	1 770	52	406.1	± 2	92	81
vi)	9.6-1770-P	9.6	1 770	55	429.6	± 2	97.4	85.7
vii)	11.0-1770-P	11.0	1 770	70	546.7	± 2	124	109
viii)	12.5-1770-P	12.5	1 770	93	726.3	± 2	165	145
ix)	12.7-1770-P	12.7	1 770	100	781	± 2	177	156
x)	15.2-1770-P	15.2	1 770	139	1 086	± 2	246	216
xi)	15.7-1770-P	15.7	1 770	150	1 172	± 2	266	234
xii)	18.0-1770-P	18.0	1 770	200	1 562	± 2	354	312
xiii)	15.2-1860-C	15.2	1 820	165	1 289	± 2	300	264
xiv)	6.9-1860-P	6.9	1 860	29	226.5	± 2	53.9	47.4
xv)	7.0-1860-P	7.0	1 860	30	234.3	± 2	55.8	49.1
xvi)	8.0-1860-P	8.0	1 860	38	296.8	± 2	70.7	62.2
xvii)	9.0-1860-P	9.0	1 860	50	390.5	± 2	93	81.8
xviii)	9.3-1860-P	9.3	1 860	52	406.1	± 2	96.7	85.1
xix)	9.6-1860-P	9.6	1 860	55	429.6	± 2	102	89.8
xx)	11.0-1860-P	11.0	1 860	70	546.7	± 2	130	114
xxi)	11.3-1860-P	11.3	1 860	75	585.8	± 2	140	123
xxii)	12.5-1860-P	12.5	1 860	93	726.3	± 2	173	152
xxiii)	12.9-1860-P	12.9	1 860	100	781	± 2	186	164
xxiv)	13.0-1860-P	13.0	1 860	102	796.6	± 2	190	167
xxv)	15.2-1860-P	15.2	1 860	139	1 086	± 2	259	228
xxvi)	15.7-1860-P	15.7	1 860	150	1 172	± 2	279	246
xxvii)	12.7-1860-C	12.7	1 860	112	874.7	± 2	208	183
xxviii)	15.2-1860-C	15.2	1 860	165	1 289	± 2	307	270
xxix)	9.0-1960-P	9.0	1 960	50	390.5	± 2	98	87.2
xxx)	9.3-1960-P	9.3	1 960	52	406.1	± 2	102	90.8
xxxix)	9.6-1960-P	9.6	1 960	55	429.6	± 2	108	96.1

Table 2 (Concluded)

Sl No.	Strand Designation	Diameter	Tensile Strength	Cross-Sectional Area	Mass Per Metre	Tolerance on Nominal Mass Per Metre	Minimum Breaking Load	Minimum 0.2 Percent Proof Load
		mm	MPa	mm ²	g/m	Percent	kN	kN
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
xxxii)	11.0-1960-P	11.0	1 960	70	546.7	± 2	137	122
xxxiii)	11.3-1960-P	11.3	1 960	75	585.8	± 2	147	131
xxxiv)	12.5-1960-P	12.5	1 960	93	726.3	± 2	182	162
xxxv)	12.9-1960-P	12.9	1 960	100	781	± 2	196	174
xxxvi)	13.0-1960-P	13.0	1 960	102	796.6	± 2	200	178
xxxvii)	15.2-1960-P	15.2	1 960	139	1 086	± 2	272	242
xxxviii)	15.7-1960-P	15.7	1 960	150	1 172	± 2	294	262
xxxix)	6.4-2060-P	6.4	2 060	25	195.3	± 2	51.5	45.8
xl)	6.9-2060-P	6.9	2 060	29	226.5	± 2	58.1	51.7
xli)	7.0-2060-P	7.0	2 060	30	234.3	± 2	61.8	55
xlii)	8.6-2060-P	8.6	2 060	45	351.5	± 2	92.7	82.5
xliii)	11.3-2060-P	11.3	2 060	75	585.8	± 2	155	138
xliv)	12.5-2060-P	12.5	2 060	93	726.3	± 2	192	171
xliv)	12.9-2060-P	12.9	2 060	100	781	± 2	206	183
xlvi)	6.9-2160-P	6.9	2 160	29	226.5	± 2	60.9	54.2

NOTES

1 The modulus of elasticity may be taken as 195 GPa.

2 The nominal cross-sectional area and the nominal mass of strand are given for information only. The method for measuring nominal cross-sectional area and the nominal mass per unit length of the strand is given in Annex B.

6.2 Physical and Mechanical Properties

6.2.1 General

While conducting the tests for mechanical properties as specified in 6.2.2 to 6.2.4, premature failure of the test specimens may result if there is any appreciable notching, cutting or bending of the specimen by the gripping devices of the testing machine. Errors in testing may result, if all the wires constituting the strand are not loaded uniformly. In order to minimize these difficulties, the following should be adopted:

- Length of grip should be at least equal to one lay length of the strand being tested,
- Wedge and barrel type of grips should be avoided,
- Grip jaws should be semi-circular with serrations for developing adequate grip and ensuring no slippage. The above method of gripping along with other suggested methods has been described in Annex C,
- Gripping force should be developed either hydraulically or pneumatically,
- Additional inserts may be used to prevent biting of wire surface, and
- Load should be applied gradually.

6.2.1.1 Tests in which fracture of any of the wires occur within a distance of 3 mm from the jaws of the machine shall be discarded, if the results do not comply with the requirements of this standard. In such cases, the test shall be repeated.

6.2.2 Breaking Strength and 0.2 Percent Proof Load

6.2.2.1 The breaking strength and 0.2 percent proof load of the strand shall be determined in accordance with IS 1608 (Part1) and shall be not less than the values specified in Table 2.

6.2.2.2 Alternatively by mutual agreement between the purchaser and the manufacturer, the load at 1.0 percent extension may be determined. In this test, an initial load equivalent to 10 percent of specified minimum breaking strength shall be applied to the test piece and a sensitive extensometer then attached. The dial of the latter shall be adjusted to read 0.001 mm/mm of the gauge length to represent the extension due to the initial load. The load shall be increased until the extensometer shows an extension corresponding to 1.0 percent. The load at this extension shall not be less than the minimum 0.2 percent proof load specified in Table 2. In case of dispute, 0.2 percent proof load shall apply.

6.2.3 Elongation

The total elongation under load shall not be less than 3.5 percent on a minimum gauge length of 600 mm. The total elongation shall be measured by a suitable extensometer which is attached to the test piece, after an initial load equivalent to 10 percent of the required minimum breaking load as specified in Table 2 has been applied.

The dial of the extensometer shall be adjusted to read 0.001 mm/mm of the initial gauge length, G_0 to represent the extension due to the initial load. The load shall be increased until the extensometer shows an extension corresponding to 1.0 percent. The reading on the measuring scale mounted on the machine shall be noted as R_1 or the gauge length between the jaws of the machine shall be measured with a measuring tape as G_1 .

Following an extension of 1.0 percent, the extensometer should be removed. The loading shall be continued till at least any one wire of the strand breaks. Once the wire breaks, the breaking load on the machine shall be noted and the machine shall be stopped. The second reading on the measuring scale shall be noted as R_2 or the gauge length at the time of breaking of wire between two grips shall be measured as G_2 . The elongation value is then determined by the movement between the jaw gripping the test piece on the new base length of jaw-to-jaw distance to which will be added the value of 1.0 percent determined by the extensometer.

$$\text{Elongation, in percent} = 1.0 + \left(\frac{R_2 - R_1}{G_0} \times 100 \right)$$

or

$$\text{Elongation, in percent} = 1.0 + \left(\frac{G_2 - G_1}{G_0} \times 100 \right)$$

6.2.4 Relaxation Properties

6.2.4.1 Low relaxation strand, when initially loaded to 70 percent of specified minimum breaking strength of the strand, shall have relaxation losses of not more than 1.8 percent after 100 h and not more than 2.5 percent after 1 000 h when tested under the conditions given in **6.2.4.2** to **6.2.4.8**.

Relaxation test for 1 000 h shall be a type approval test and shall be carried out at least once in a year or whenever there is any change in the process of manufacture, for each type of strand.

6.2.4.2 If required, the manufacturer shall provide relaxation evidence from the manufacturer's records of tests on similarly dimensioned strand of the same grade.

6.2.4.3 The temperature of the test piece shall be maintained at 20 ± 2 °C.

6.2.4.4 The test piece shall not be subjected to loading prior to the relaxation test.

6.2.4.5 The initial load shall be applied uniformly over a period of not less than 3 min and not more than 5 min and the gauge length shall be maintained constant. Load relaxation readings shall commence 1 min after application of the total load.

6.2.4.6 Over-stressing of the test piece during the loading operations shall not be permitted.

6.2.4.7 The duration of the test shall be 1 000 h or a short-computed period of 100 h, extrapolated to 1 000 h, which can be shown by records to provide similar relaxation values.

6.2.4.8 The test gauge length should be at least 40 times the nominal strand diameter.

6.3 Straightness of Strand

The bow height (h_b) which indicates the straightness of the strand shall be determined by measuring in the plane of the bow the distance between the highest point on the bow and the line joining the ends of a rule of 1 m long in contact with the prestressing steel lying on a flat horizontal surface with a flatness tolerance of 1 mm/m (see Fig. 1). The maximum bow height shall be not greater than 25 mm.

6.4 Behaviour During Cutting

When the finished strand is cut with a disc cutter, the individual wires either shall not unravel or shall be capable of being repositioned without difficulty.

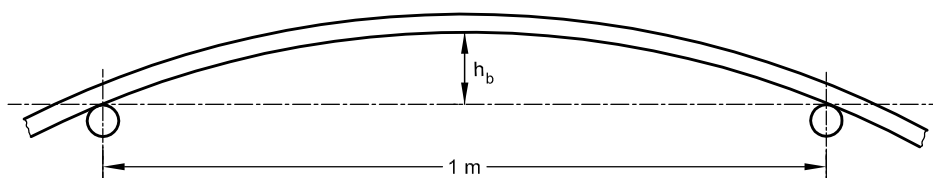


FIG. 1 STRAIGHTNESS OF STRAND

7 SAMPLING AND CRITERIA FOR CONFORMITY

7.1 Selection of Test Samples

Test samples of sufficient length to permit the tests for breaking load, 0.2 percent proof load and elongation shall be cut from one end of a coil selected at random from a group of every 5 numbers of coils; but sample size shall not be less than 2 from each lot.

7.1.1 The test sample shall not be detached from the coil or length of strand, except in the presence of purchaser or his authorized representative.

7.1.2 Before test samples are selected, the manufacturer or supplier shall furnish the purchaser or his authorized representative with copies of the mill records giving number of coils in each cast with sizes as well as the identification marks, whereby each coil can be identified.

7.1.3 If required by the purchaser, 100 h relaxation test shall be carried out on a sample from the lot.

7.2 Criteria for Conformity

7.2.1 Should any sample fail any of the tests, by agreement between the manufacturer and the purchaser, two additional test samples from the same end of the same coil shall be taken and subjected to the test or tests in which the original sample failed. Should both additional samples pass the test or tests, the coil from which they were taken shall be deemed to comply with the requirements of this standard. Should either of them fail, the coil shall be deemed not to comply.

7.3 Should 10 percent or more of the selected coils fail to fulfill the requirement of this standard, the parcel from which they were taken shall be deemed not to comply with this standard.

8 DELIVERY, INSPECTION AND TESTING FACILITIES

8.1 Unless otherwise specified, general requirements relating to the supply of material, inspection and testing shall conform to IS 1387.

8.2 The purchaser or his authorized representative shall be at liberty to inspect and verify the steel maker's certificate of cast analysis at the premises of the manufacturer or supplier; when the purchaser requires an actual analysis of finished material, this shall be made at a place agreed to between the purchaser and the manufacturer or the supplier.

8.3 Manufacturer's Certificate

In the case of strands which have not been inspected at the manufacturer's work, the manufacturer or supplier, as the case may be, shall supply the purchaser or his authorized representative with the certificate stating the process of manufacture and also the test sheet signed by the manufacturer giving the result of each mechanical test, 0.2 percent proof load and the chemical composition, if required. Each test sheet shall indicate the number or identification mark of the cast to which it applies, corresponding to the number or identification mark to be found on the material.

9 PACKING

9.1 Unless otherwise agreed to between the purchaser and the supplier the strands shall be supplied as indicated in **9.1.1** or **9.1.2**.

9.1.1 Strand shall be supplied in reels or in reelless packs having a minimum core diameter of 600 mm. Lengths on reels or reelless packs shall be as per agreement between the manufacturer and the purchaser.

9.1.2 The coil shall be securely strapped to prevent distortion of the coil in transit and unless otherwise specified, the coil shall be protected against damage in transit by wrapping with hessian.

9.1.3 By mutual agreement between the purchaser and the manufacturer, water soluble oil may be applied on strands.

10 MARKING

10.1 Each reel or reel-less pack shall carry a label giving the following details:

- a) Manufacturer's name or trade mark or brand name;
- b) Coil number; and
- c) Nomenclature of the strand (*see 5*).

10.2 BIS Certification Marking

Each coil containing the strands conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations framed thereunder, and the coil containing the strands may be marked with the Standard Mark.

ANNEX A*(Clauses 4.2 and 6.1.1)***MEASUREMENT OF LENGTH OF LAY, NOMINAL DIAMETER OF STRAND AND DIFFERENCE IN DIAMETER OF CENTRE WIRE AND SURROUNDING WIRE OF STRAND****A-1 LENGTH OF LAY OF STRAND**

The sample shall be kept horizontally on the table and a plain paper shall be put on the sample. A carbon paper shall then be placed in a reverse manner on top of the plain paper and rubbed gently on the sample with a round object. Impressions of wire will be seen on the paper in the form of slanted lines. A vertical line shall be drawn at the starting end of any one marking/wire impression and another vertical line shall be drawn at the end of consecutive sixth marking/wire impression. The distance between two straight lines shall be measured. The procedure shall be repeated at three different places and three such readings shall be taken. The average of these three readings shall be the length of lay of the strand.

A-2 NOMINAL DIAMETER

For measuring nominal diameter of seven-wire strand, the micrometer or vernier head shall be kept axially over the crown of outer wires so as to cover two surrounding wires and the centre wire and then the reading shall be taken. Three such readings in three directions shall be taken. The average of those readings shall be the nominal diameter of seven-wire strand.

A-3 PERCENTAGE DIFFERENCE IN DIAMETER OF CENTRE WIRE AND SURROUNDING WIRE

The diameter of all the six surrounding wires and the centre wire of the strand shall be measured. The difference in diameter of centre wire and surrounding/outer wire of the strand shall be calculated as below:

$$\text{Percentage difference} = \frac{\text{Diameter of centre wire} - \text{Maximum outer wire diameter}}{\text{Maximum outer wire diameter}} \times 100$$

ANNEX B*(Table 2)***MEASUREMENT OF NOMINAL CROSS-SECTIONAL AREA AND NOMINAL MASS PER UNIT LENGTH OF STRAND****B-1 NOMINAL CROSS-SECTIONAL AREA**

The strand sample shall be unraveled to separate individual wires. The diameter of individual wires, that is, six surrounding wires and one centre wire of the strand shall be measured and the cross-sectional area of each wire shall then be computed. The sum of the areas of individual wires is the nominal cross-sectional area of the strand.

B-2 NOMINAL MASS PER UNIT LENGTH OF STRAND

A sample of 100 cm length shall be cut and its mass shall be measured, in kg. The length of the core wire in that sample shall then be measured, in metres. The nominal mass per unit length of a seven-wire strand, in kg/m shall be the ratio of the obtained mass of the sample to the measured length of the centre/core wire.

ANNEX C

(Clause 6.2.1)

SUGGESTED METHODS OF GRIPPING FOR TENSILE TESTING OF STRANDS

C-1 The true mechanical properties of the strand are determined by a test in which fracture of the specimen occurs in the free span between the jaws of the testing machine. Therefore, it is desirable to establish a test procedure with suitable apparatus that consistently produces such results. Due to inherent physical characteristics of individual machines, it is not practical to recommend a universal gripping procedure that is suitable for all testing machines. Therefore, it is necessary to determine which of the methods of gripping described below is most suitable for the testing equipment available.

C-1.1 Special Grips with Smooth, Semi-Cylindrical Grooves

The radius of curvature of the grooves is approximately the same as the radius of the strand being tested, and is located 0.8 mm above the flat face of the grip. This prevents the two grips from closing tightly when the specimen is in place. The grooves and the gripped portions of the specimen are coated with an abrasive slurry which holds the specimen in the smooth grooves, preventing slippage. The slurry consists of abrasive, such as Grade 3-F aluminium oxide and a carrier, such as water or glycerin.

C-1.2 Standard V-Grips with Serrated Teeth

The number of teeth should be approximately 6 to 12 per centimetre and the minimum effective gripping length should be approximately 10 cm.

C-1.3 Standard V-Grips with Serrated Teeth Using Cushioning Material

The number of teeth and minimum effective gripping length should be as given in **C-1.2**. In this method, some material is placed between the grips and the specimen to minimize the notching effect of the teeth. Materials like lead foil, aluminium foil, carborundum cloth, emery cloth, etc are being used for this purpose.

The type and thickness of material required is dependent on the shape, condition, and coarseness of the teeth.

C-1.4 Standard V-Grips with Serrated Teeth Using Special Preparation of the Gripped Portions of the Specimen

The number of teeth and minimum effective gripping length should be as given in **C-1.2**. In this method, some special preparation is done in the gripped portions of the specimen so as to minimize the notching and cutting effect of the teeth. One of the methods used is tinning, in which the gripped portions are cleaned, fluxed, and coated by multiple dips in molten tin alloy held just above the melting point. Another method of preparation is encasing the gripped portions in metal tubing or flexible conduit, using epoxy resin as the bonding agent. The encased portion should be approximately twice the length of lay of the strand.

C-1.5 Standard Sockets of the Type Used for Wire Rope

The gripped portions of the specimen are anchored in the sockets with zinc. The special procedures for socketing usually employed in the wire rope industry should be followed.

C-1.6 Dead-End Eye Splices

These devices are available in sizes designed to fit each size of strand to be tested.

C-1.7 Chucking Devices

Use of chucking devices of the type generally employed for applying tension to strands in casting beds is not recommended for testing purposes.

NOTE— If the molten-metal temperatures employed during hot-dip tinning or socketing with material are too high, over approximately 370 °C, the specimen may be heat-affected with a subsequent loss of strength and ductility. Careful temperature controls should be maintained if such methods of specimen preparation as in **C-1.4** and **C-1.5** are used.

ANNEX D*(Foreword)***COMMITTEE COMPOSITION**

Concrete Reinforcement Sectional Committee, CED 54

<i>Organization</i>	<i>Representative(s)</i>
In Personal Capacity, New Delhi	SHRI G. SHARAN (<i>Chairman</i>)
Central Public Works Department, New Delhi	SHRI D. K. GARG SHRI N. K. BANSAL (<i>Alternate</i>)
Central Water Commission, New Delhi	DIRECTOR (HCD-NW & S) DIRECTOR (HCD-N & W) (<i>Alternate</i>)
Construction Industry Development Council, New Delhi	SHRI SUNIL MAHAJAN SHRI O. P. GUPTA (<i>Alternate</i>)
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CSIR-Central Road Research Institute, New Delhi	DIRECTOR SHRI S. S. GAHARWAR (<i>Alternate</i>)
CSIR-Structural Engineering Research Centre, Chennai	DR B. H. BHARATH KUMAR MS SMITHA GOPINATH (<i>Alternate</i>)
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Delhi Metro Rail Corporation, New Delhi	SHRI NAVNEET KUMAR KOTHARI SHRI SANJEEV KUMAR GARG (<i>Alternate</i>)
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Dextra India Pvt Ltd, Mumbai	SHRI SUNIL DESAI SHRI JITENDRA H. PATHAK (<i>Alternate</i>)
Engineers India Limited, New Delhi	SHRI RAJANJI SRIVASTAVA SHRI DEEPAK AGRAWAL (<i>Alternate</i>)
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Hindustan Construction Company, Mumbai	SHRI SATISH KUMAR SHARMA SHRI MUKESH VALECHA (<i>Alternate</i>)
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Indian Institute of Technology Roorkee, Roorkee	PROF PRAMOD KUMAR GUPTA PROF AKHIL UPADHYAY (<i>Alternate</i>)
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Jindal Steel and Power Ltd, Gurugram	SHRI ASHWANI KUMAR SHRI LAKSHMI NARASIMHAN (<i>Alternate</i>)
JSW Steel Ltd, Raigad	SHRI PRATAP K. PATRA
Larsen and Toubro Ltd (ECC Construction Division), Chennai	SHRI S. KANAPPAN SHRI STHALADIPTI SAHA (<i>Alternate</i>)
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National Highways Authority of India, New Delhi	SHRI R. K. PANDEY SHRI S. K. MISHRA (<i>Alternate</i>)
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(Continued from second cover)

Provisions in this standard are at variance with similar provisions in the above international standards, in view of:

- a) Geographical factors which determine the earthquake zoning and consequently the structural design considerations, structural design method/principles adopted, the design parameters and required material properties;
- b) Technological factors associated with the process of manufacture of the product, which influence the product characteristics; and
- c) Construction techniques and practices adopted in the country, the equipment used and the skill level of construction workers which also influence the product characteristics.

The major deviations are:

- a) The requirement for minimum diameter of central wire of strand is lower and strand construction is different, in view of the prevailing manufacturing practices;
- b) Nominal diameter of strand with applicable tolerance has been specified and nominal mass has been given for information only;
- c) 0.2 percent proof load has been specified in line with similar requirement in other steel reinforcement standards; and
- d) Requirements such as for crack and fatigue test have not been specified.

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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